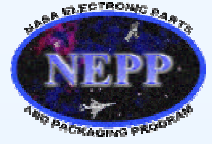# Single Event Transient (SET) in Linear Devices, Testing Guidelines

C. Poivey, S. Buchner,J. Howard, C. Seidleck,

K. LaBel, H. Kim, J. Forney
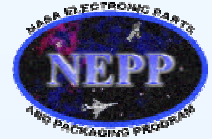
NASA GSFC, Greenbelt MD 20771

Outline
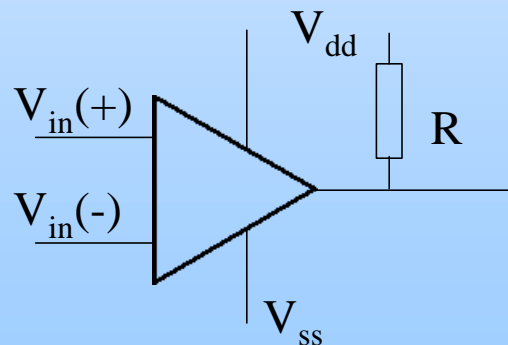
- Introduction
- Lessons learned
  - Irradiation conditions
  - Bias conditions
  - Test set-up
  - Data analysis and reporting
- Testing guidelines

Introduction

- SETs are momentary glitches in the output voltage of a circuit caused by ions passing through sensitive nodes in the circuit

- SETs can occur in both digital and analog circuits

V_{dd}

$V_{in}(+)$

$V_{in}(-)$

R

V_{ss}
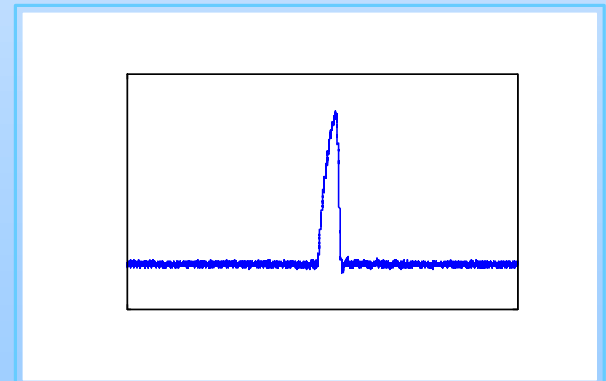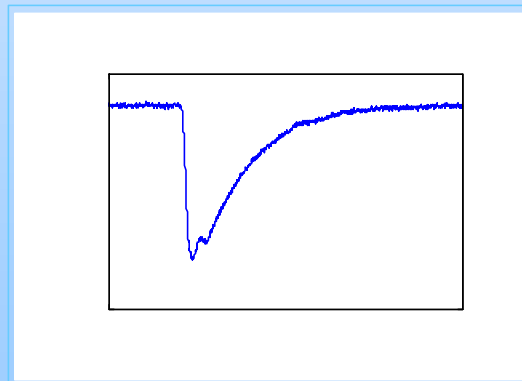
Introduction

• Need for test guidelines is to ensure

– that all SET testing of linear circuits be done by a test engineer who is fully aware of all conditions that affect the results

– the results can become part of a radiation effects data base that can be used by others who also want to use the part in space.
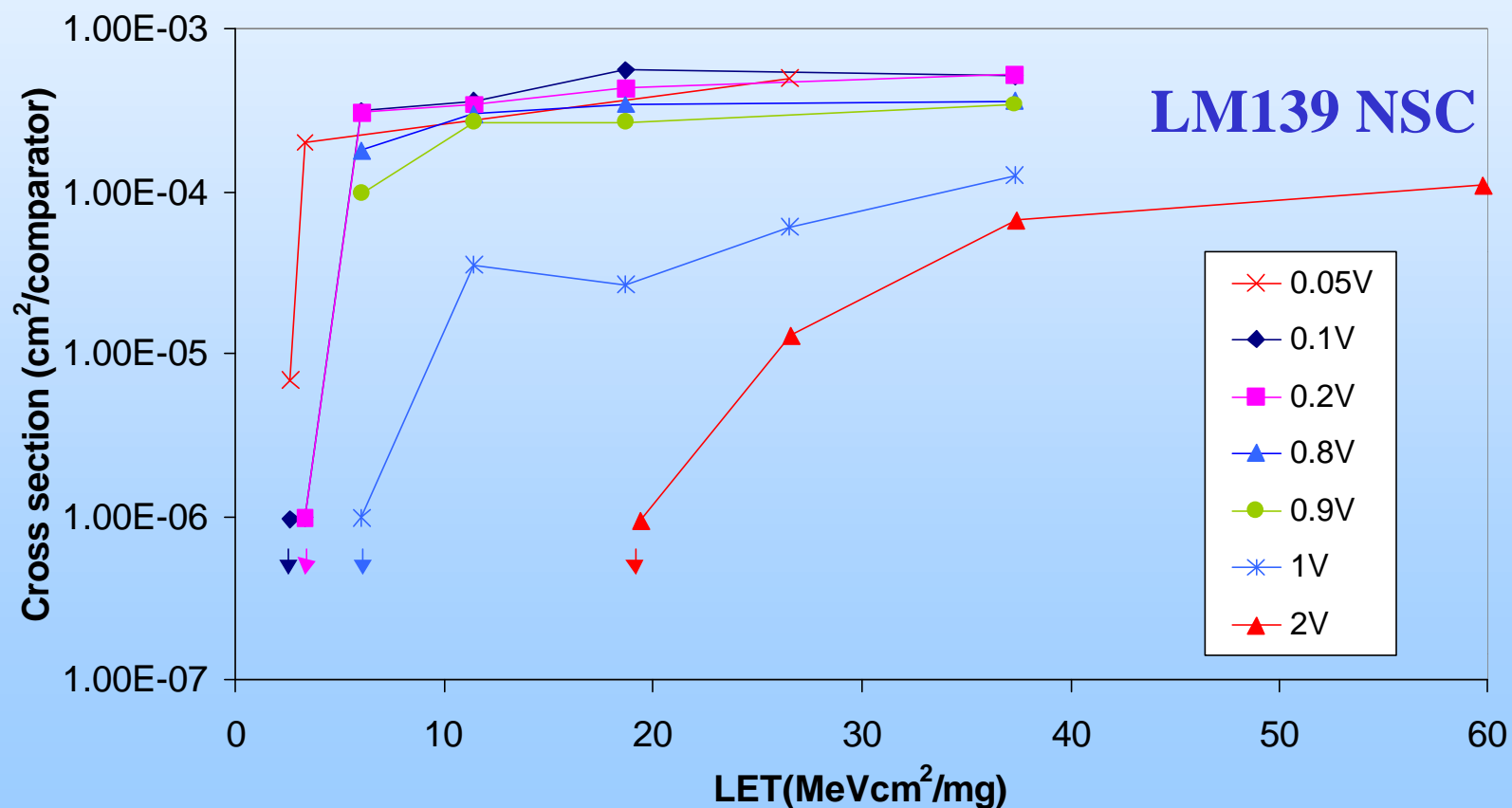
Introduction

- Numerous SET tests have been performed during the last two years by NASA-GSFC in order to define a low cost conservative test methodology.

- This talk presents both the lessons learned during these tests and the proposed testing guidelines.
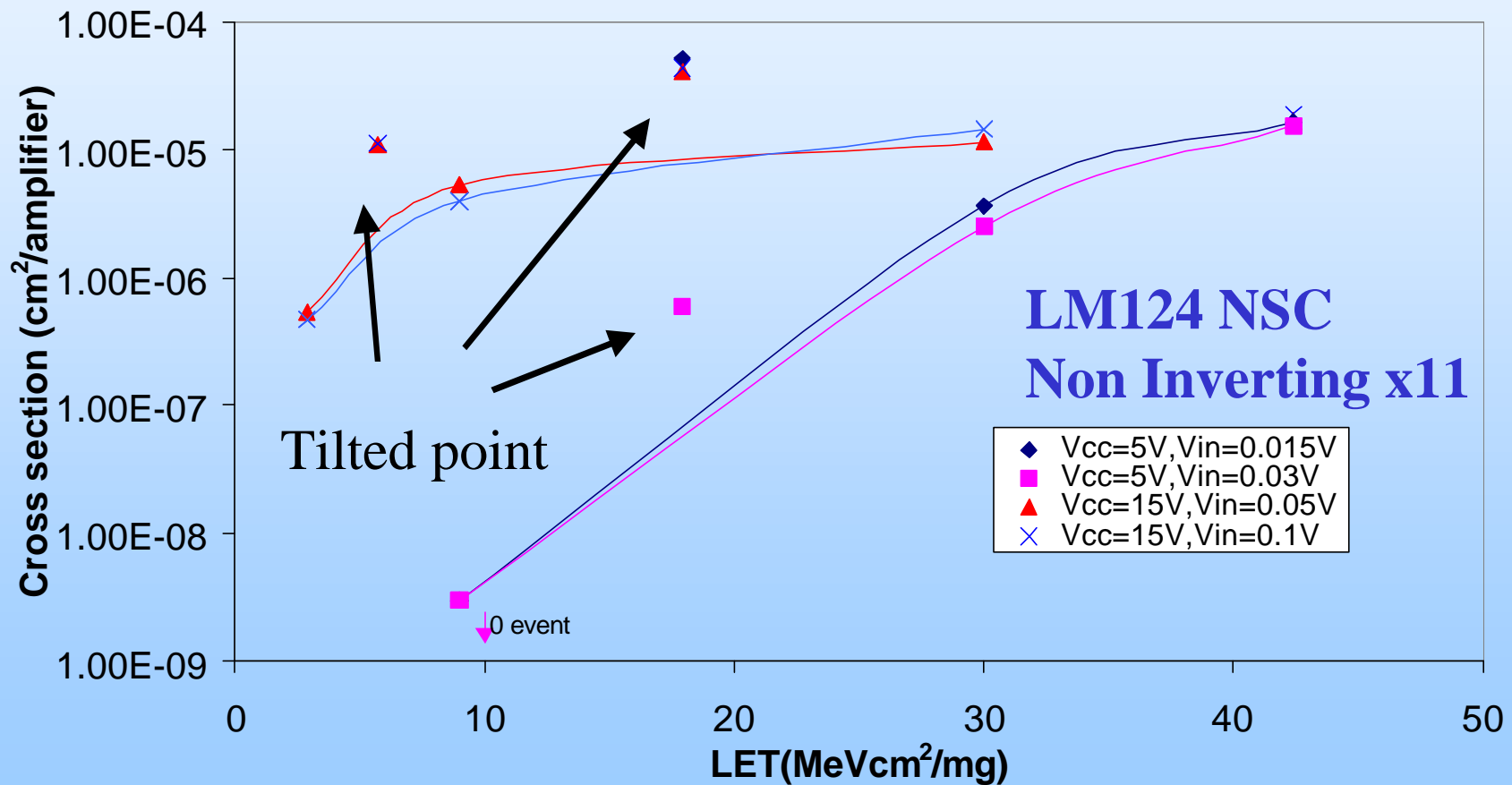
Bias conditions have a significant effect on device sensitivity
Input Voltage

LM139 NSC

Legend:
- 0.05V
- 0.1V
- 0.2V
- 0.8V
- 0.9V
- 1V
- 2V

X-axis: LET(MeVcm^2/mg)
Y-axis: Cross section (cm^2/comparator)

Bias conditions have a significant effect on device sensitivity
Power Supply Voltage

LM124 NSC
Non Inverting x11

Tilted point

0 event

Cross section (cm^2/amplifier)

LET(MeVcm^2/mg)

- ◆ Vcc=5V,Vin=0.015V
- ■ Vcc=5V,Vin=0.03V
- ▲ Vcc=15V,Vin=0.05V
- ✕ Vcc=15V,Vin=0.1V

There is not always a dependence on tilt angle

RPP Method?

Differential Input Bias
- .05 Volts
- .02 Volts
- .10 Volts

National LM111
LET = 13.23 MeV cm^2/mg
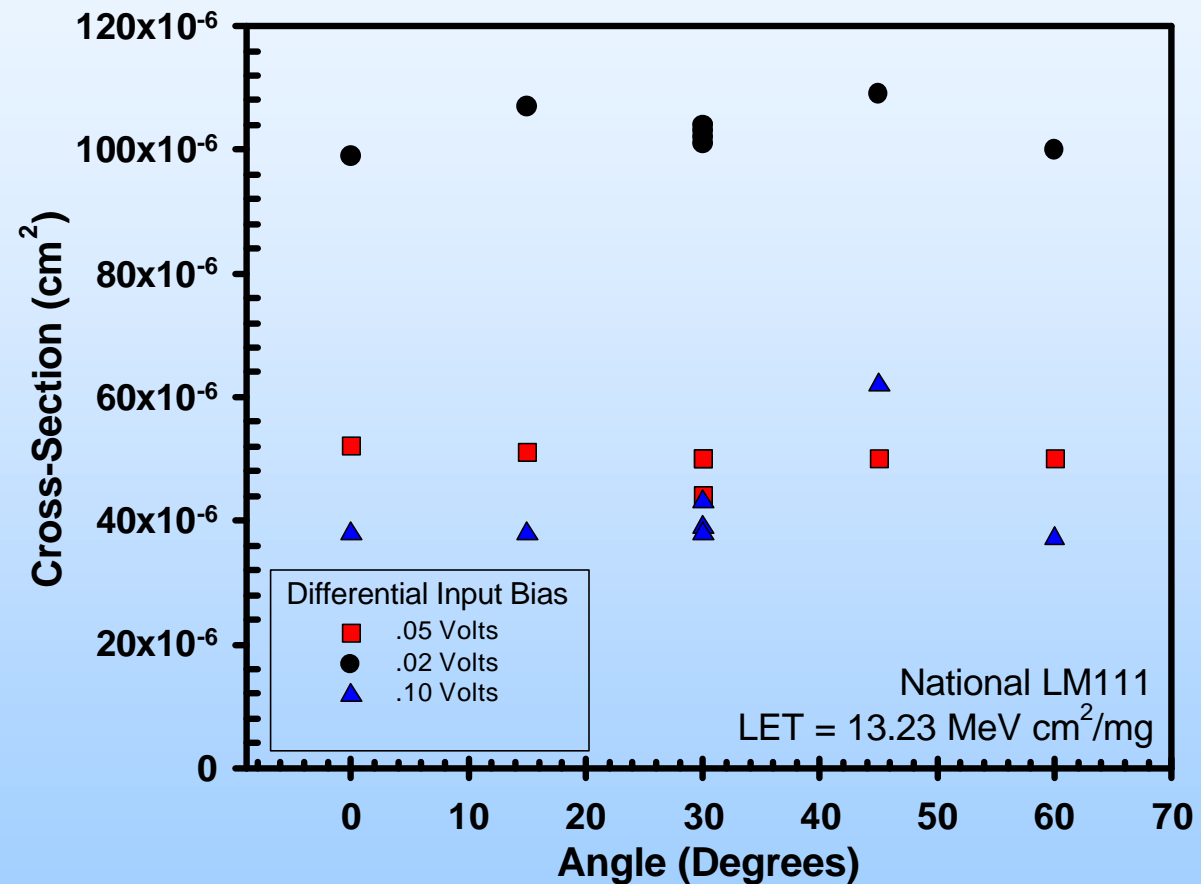
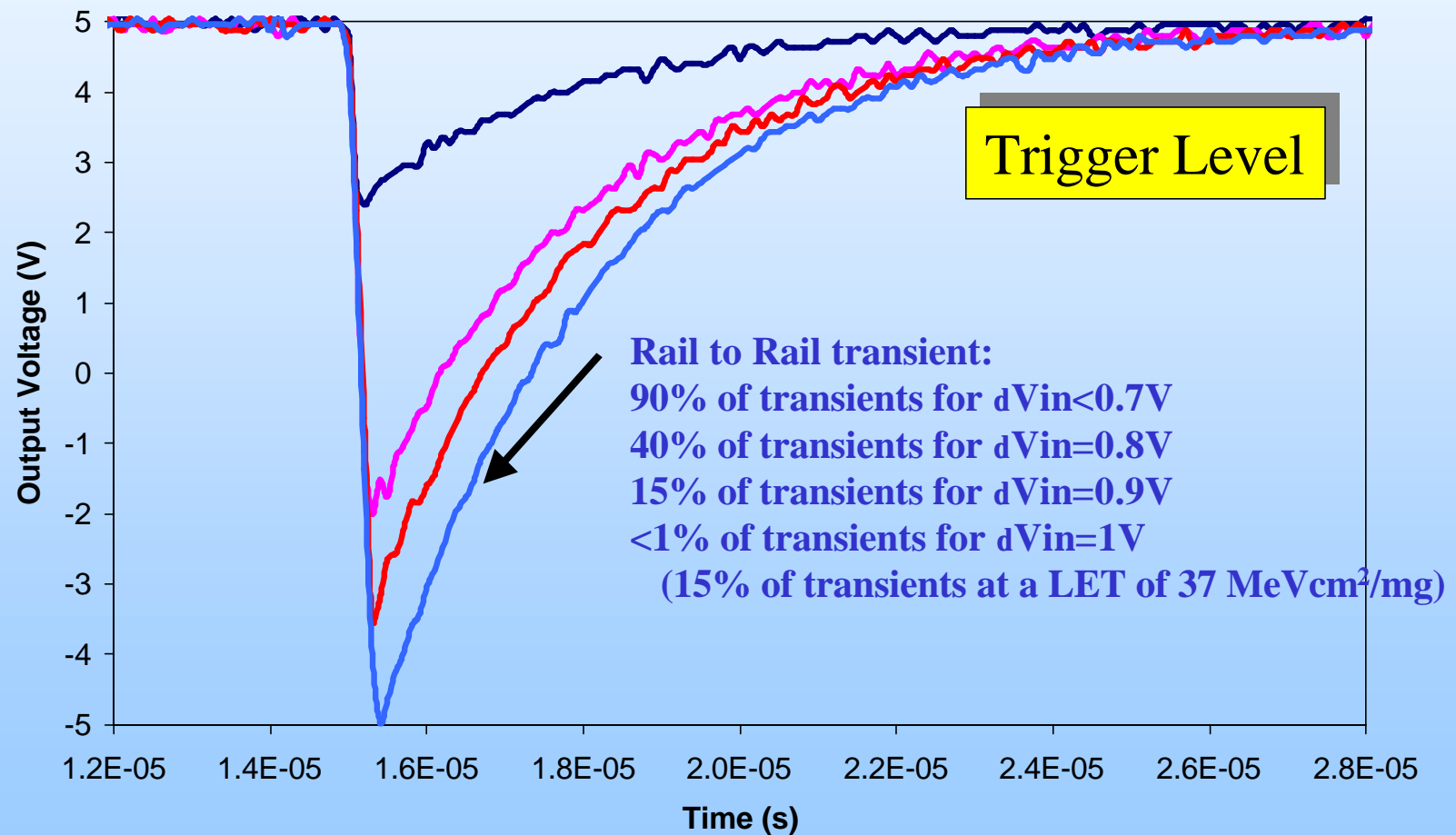*Data provided by M. Savage, NAVSEA CRANE*

Bias conditions have a significant effects on transient waveform

LM139 Vcc=+/-5V TAMU LET=18.7 MeVcm^2/mg

Trigger Level

Rail to Rail transient:
90% of transients for dVin<0.7V
40% of transients for dVin=0.8V
15% of transients for dVin=0.9V
<1% of transients for dVin=1V
   (15% of transients at a LET of 37 MeVcm^2/mg)

Various transient waveforms can be collected

LM124 Non inverting gain x11 Vcc=+/-15V Vin=0.5V
TAMU LET= 30 MeVcm2/mg

103 events

49
(6V;380ns)

2
(3.4V;60ns)

29

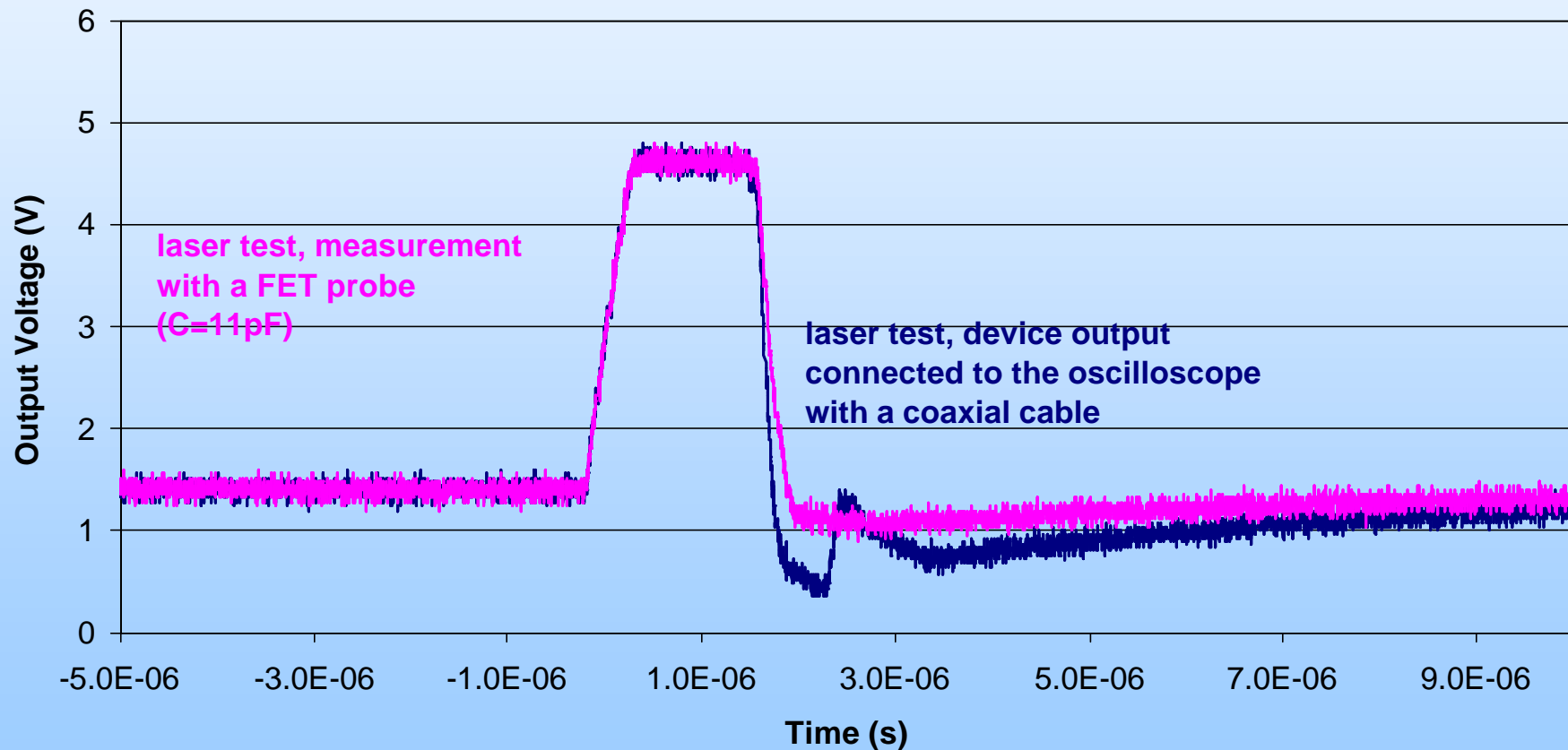(1.8V;2.3us)

23

(1.4V;145ns)

Output Voltage (V)

Time (s)
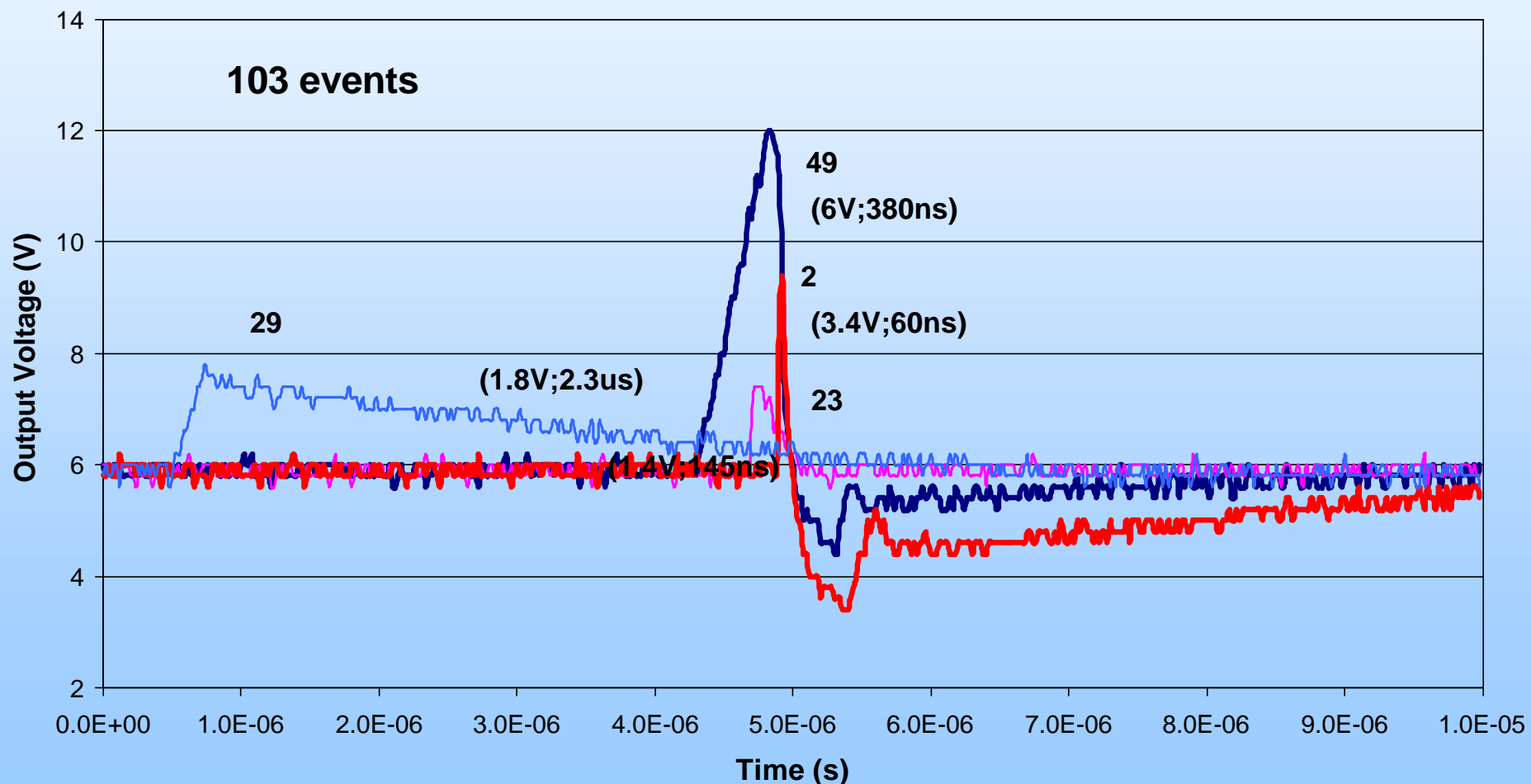
Transient characteristics vary with LET

LM124 Non inverting gain x11 Vcc=+/-15V Vin=0.5V
TAMU LET
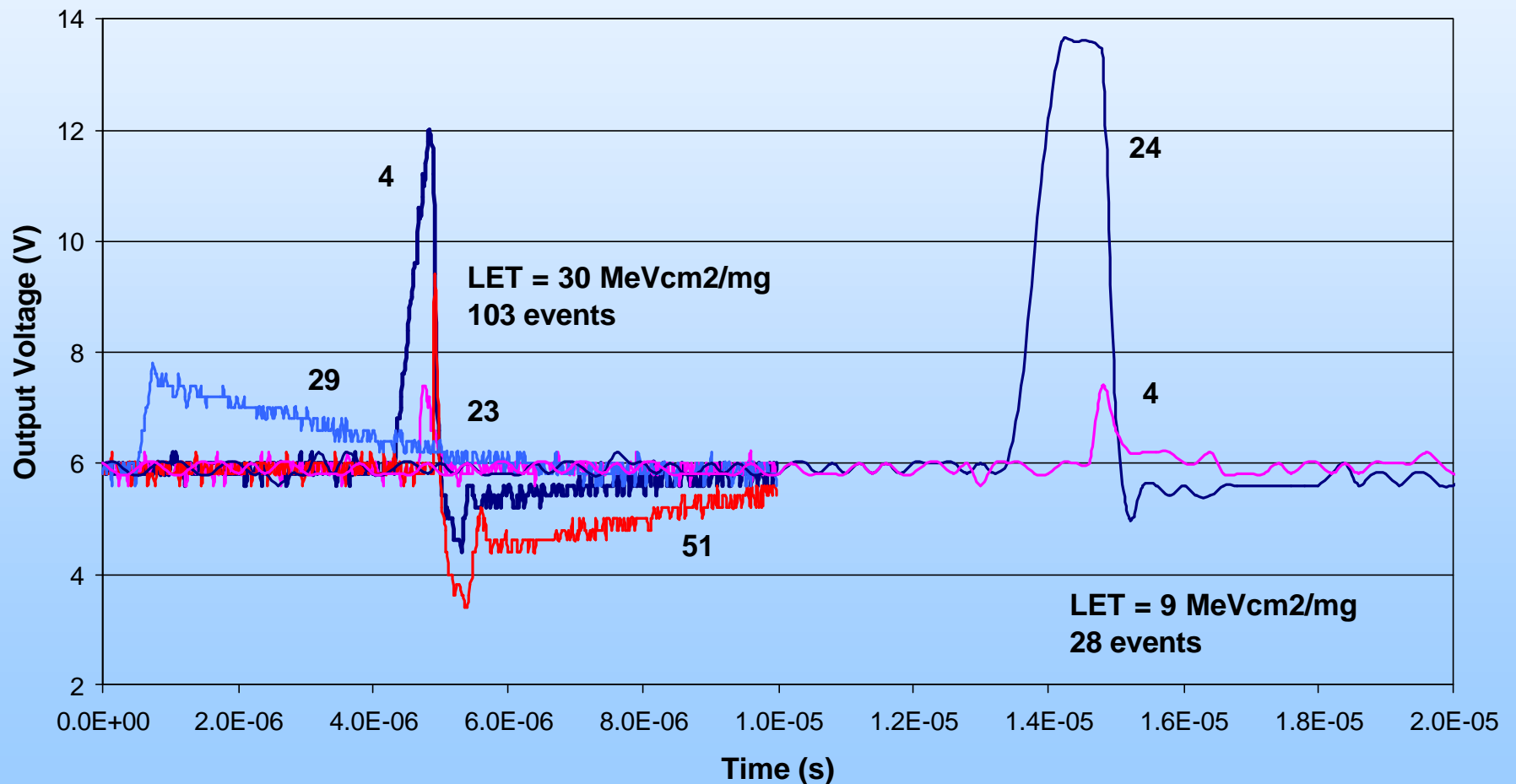
Test set-up may have significant effect on the collected transient waveforms

Output Voltage (V) (y-axis, 0 to 6)

Time (s) (x-axis, -5.0E-06 to 9.0E-06)

laser test, measurement with a FET probe (C=11pF)

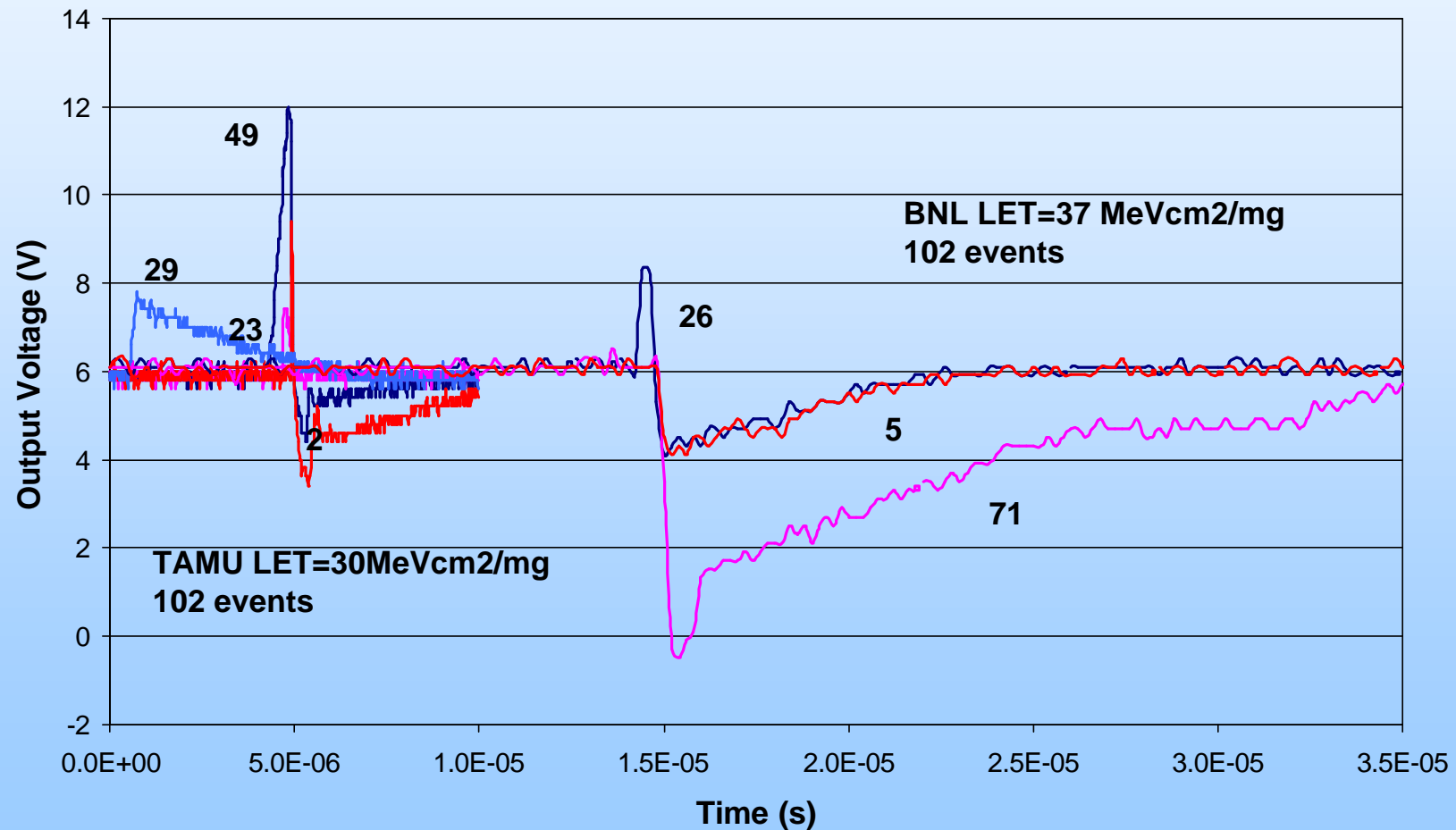laser test, device output connected to the oscilloscope with a coaxial cable

Test set-up may have significant effect on the collected transient waveforms

LM124 Non inverting gain x11 Vcc=+/-15V Vin=0.5V

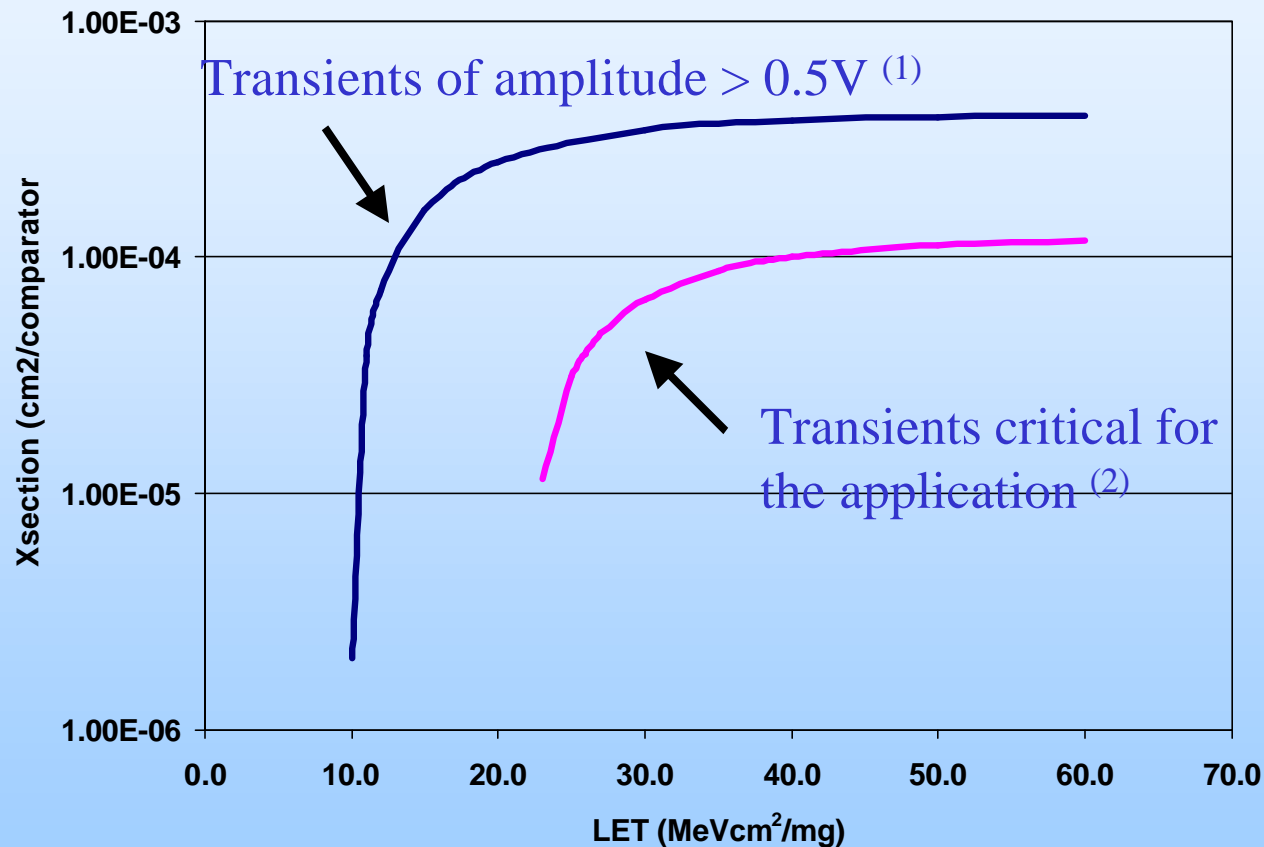# How good is the data to assess the SET impact on applications?

PM139 dVin=1V

Transients of amplitude > 0.5V [1]

Transients critical for the application [2]

Xsection (cm2/comparator) (y-axis)

LET (MeVcm^2/mg) (x-axis)

(1) After A. Johnston, IEEE Trans. on Nuc. Sci., vol. 47-6, p2624, Dec. 2000.
(2) After Boeing data.

Testing Guidelines
Irradiation Conditions

- Flux must remain low enough not to cause pile-up of data collection

- A sufficient number of transients needs to be collected to get a significant number of all the different transient waveforms:

  >400 events

- Minimum penetration range of ions:

  > 30 μm

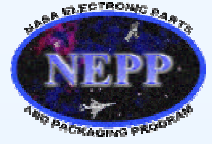# Testing Guidelines
Bias Conditions

- A large set of different bias conditions is necessary to try to understand the device behavior and define worst case bias conditions.

- It is not often possible to define worst case bias conditions.

- It is often necessary to test the parts in their application conditions.
  - Laser testing and modeling may be useful to check other bias conditions.
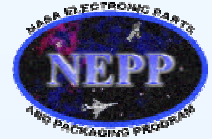
Testing Guidelines
Data collection techniques

- Care must be taken in the selection of the type of oscilloscope probe used

  – Low capacitance active FET probe.

- All the transients collected need to be stored for further analysis.

Testing Guidelines
Data Analysis & Reporting

- At minimum the report should include:
  - bias conditions

  - measurements conditions (triggering conditions)

  - the total cross section curve

  - traces of the different types of waveforms collected with worst case characteristics (amplitude, duration) and how they contribute to the total cross section curve.

Testing Guidelines
Data Analysis & Reporting
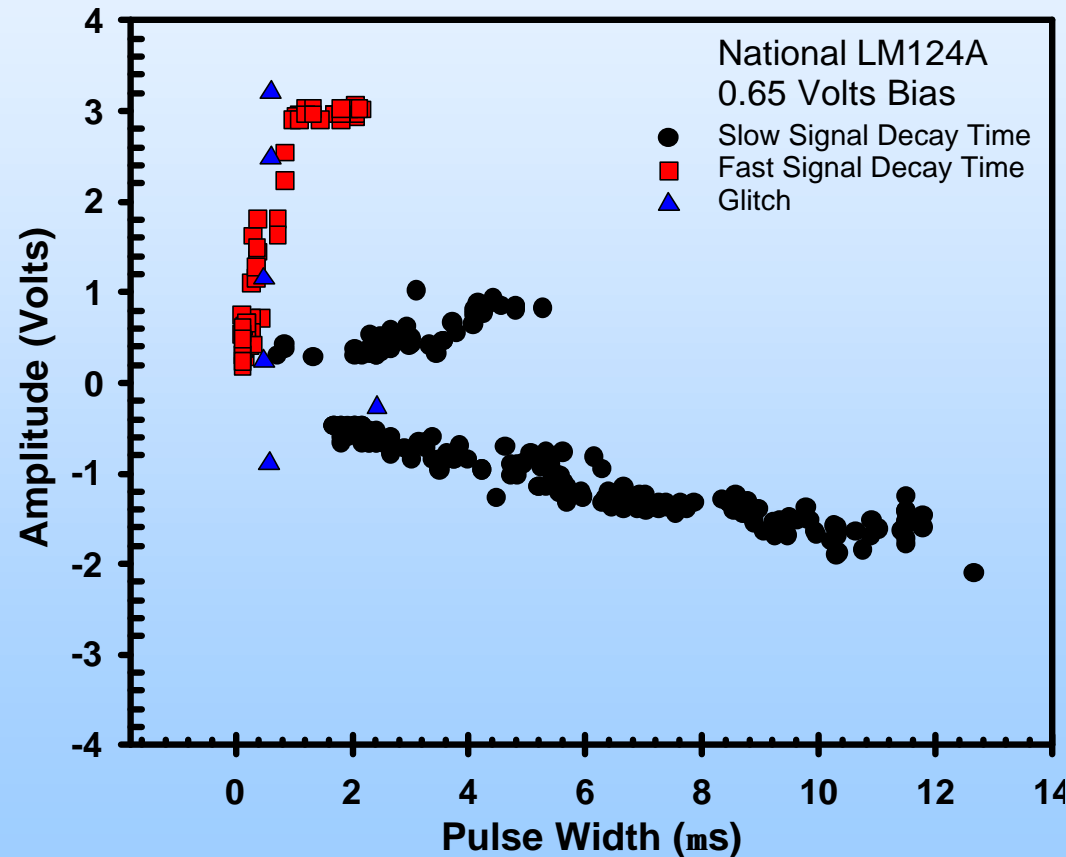
Data provided by M. Savage, NAVSEA CRANE

Summary

- SETs are voltage transients that appear on the outputs linear devices exposed to ionizing particles in space.

- Unlike SETs in devices like memories, SETs in linears can vary significantly based on operating conditions.

- NASA/GSFC has produced a document that provides guidance to the community for SET testing of linear devices.

Data provided by M. Savage, NAVSEA CRANE